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COMPLETE SPECIFICATION

Supercharging Device for Aircraft Engines

We, SOCIÉTÉ RATEAU, a French body corporate, of 40 Rue de Colisée, Paris, France, and RENÉ ANXIONNAZ, a French Citizen, of 8, Rue Nicholas Chuquet, Paris, France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The supercharging units of aviation engines, which are constituted by a turbine driven by the exhaust gases and actuating a compressor, are now capable of a very high efficiency. It follows that the power that can be supplied by the gas turbine exceeds what is strictly necessary for driving the compressor. In order to restore the power balance, a portion of the gases has been evacuated into the atmosphere, or a supplementary resistance has been created by a governor, but these arrangements involve a loss of energy.

Attempts have also been made to utilize this excess of power by intensifying the scavenging of the engine, which has been brought up to 60 per cent and even more, but the advantage of this operation is very small because the gain of power which results therefrom for the engine is negligible.

The object of the present invention is to utilize the excess of energy of the exhaust gases with the maximum efficiency in order to improve the propelling effect applied to the aircraft, which is tantamount to a material increase of the output of the motor-propeller unit.

According to a feature of the present invention, we combine a thermal engine, a turbine operated by the exhaust gases and driving a supercharging compressor and a reaction nozzle.

This arrangement permits of utilizing in the reaction nozzle the excess of power of the exhaust gases with a very high output, even when the speed of the aircraft is relatively low. It even permits of increasing the power of the motor-propeller system without modifying the engine or the fuel consumption thereof, by slightly increasing the exhaust counter-pressure. Finally; it makes it possible to obtain a good regulation of the main engine without loss of power so that said engine can thus preserve its maximum efficiency for all values of the power developed.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example, and in which:

Figure 1 shows the general arrangement of an aviation engine system made according to the present invention;

Figure 2 is a diagrammatical view showing a device for controlling the section of the nozzle above referred to;

Figures 3 and 4 are views, similar to Figure 2 showing modifications.

Figure 5 is a diagrammatical view showing the place of the regulating means;

Figure 6 shows an embodiment of the invention provided with an air by-pass leading to a point behind the gas turbine;

Figure 7 shows an embodiment in which the compressor is divided into two portions;

Figure 8 is a view similar to Figure 7, showing a modification;

Figure 9 shows an embodiment in which air is fed to the reaction nozzle without compressor;

Figure 10 is an explanatory developed view of the turbine wheel in the case of distinct and separate exhausts.

Figure 1 shows an aviation engine *a*, which, in this case is supposed to be of the usual gasoline type with a carburetter, but which might also be of any other type, either of the explosion or combustion kind.

Compressor *c* draws air at *e* through an orifice which is preferably turned in the direction in which the aircraft is travelling, in order to take advantage of the compression created by the relative velocity of air. It discharges this compressed air to the suction side of the engine, through the carburetter *f*.

The exhaust gases from the engine, which are at a pressure higher than atmospheric pressure at the altitude at

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which the aircraft is travelling are brought to the gas turbine d, where they expand in the distributing nozzles and drive wheel or wheels h. When leaving said turbine the gases again expand in reaction nozzle g, which is turned in the direction opposed to that in which the aircraft is travelling. The gases thus produce, owing to the relatively high velocity they have, a driving impulse on the aircraft. This action is equal to the product of the mass of gas delivered per second by their relative outlet velocity.

The chief advantage of this arrangement is that it produces useful work which serves in the propulsion of the aircraft, whereas the corresponding loss producing by counter-pressure at the exhaust is much lower. This may be seen from the following calculation:

Considering for instance the case of an engine of 1000 HP, having a scavenged volume of 600 litres per second, it is known that the output of the exhaust gases of this engine is approximately 1000 grammes per second. If the aircraft is flying at a height of 5000 metres, corresponding to an atmospheric pressure of 0.5 kgs. per square centimetre, the excess pressure necessary for imparting to these gases, which are supposed to be at a temperature of 500 C., a velocity of 300 metres per second is about 0.097 kg. The thrust produced by these gases is then:

$$F = m \times V = \frac{1}{9.80} \times 300 = 30.6 \text{ kgs.}$$

If the aircraft is moving with a velocity of 150 metres per second, that is to say 540 kilometres per hour, the useful work produced by this thrust is $\frac{30.6 \times 150}{75}$ that is to say 61.2 French H.P.

This corresponds approximately to a power of 80 H.P. on the propeller shaft. Now, this negative work due to the increase of the counter-pressure of 0.097 kg. which is produced is equal to the product of this excess of counter-pressure and the volume swept, that is to say $0.097 \times 600 \times 1000$ c.kgs. units $= 0.097 \times 600 \times 10$ m.kgs. $=$ 582 m.kgs. units $= 582/75$ French H.P. $=$ about 8 French H.P.

Thus, the application of the reaction nozzle in this case ensures a gain of power which is quite substantial in comparison with the results obtained by means of the devices used at the present time. Furthermore, the presence of the nozzle ensures an easy self-regulation of the propelling system. It suffices to provide the reaction nozzle with a device for varying the section of the outlet orifice thereof. It is thus possible to vary the counter-pressure created by this nozzle, and, therefore, the flow through the gas turbine for a given pressure.

This arrangement has the same advantages as the arrangement consisting in varying the section of the distributing nozzles of the gas turbine but it has the great advantage that it can be operated in flight, owing to a control placed within reach of the pilot's hand.

It can be seen that if the pilot increases the section of the nozzle, the counter-pressure produced by said nozzle is reduced. Consequently, the output of the gas turbine will tend to increase for an unchanged pressure supplied by the compressor, and therefore as the driving power of the turbine exceeds the resisting power of the compressor, the turbo-blower unit will tend to accelerate and thus increase the superchanging of the propelling engine a, which permits of increasing the power supplied by said engine when the throttle valve of carburetter f has already been, for instance, fully opened. On the contrary, the same operation in the reversed way, that is to say the reduction of the section of nozzles g, reduces the power supplied by the engine a.

This regulation of power takes place under particularly economical conditions, because if the carburetter throttle valve remains fully open, despite the reduction of the power of the engine, this avoids the losses by withdrawing which would otherwise take place if the throttle were partly closed, and the efficiency of the propelling engine remains practically constant.

This arrangement is particularly advantageous when it is combined with a by-pass connecting together the intake and the exhaust of the engine, as shown in dotted lines in Figure 1, at b.

Various means may be employed for varying the section of the outlet nozzle. Figures 2, 3 and 4 show some of these arrangements.

In the embodiment of Figure 2, a piece j of pointed shape is placed in the central part of the nozzle and it can be moved through a rod k controlled by the pilot through suitable means. By moving piece j toward the aperture of nozzle g, the section of said aperture is reduced, and inversely, it is increased when the piece is withdrawn.

In the embodiment of Figure 3, the nozzle g is divided into a plurality of elementary nozzles by means of fins or blades l. A movable shutter m operated by the pilot through any suitable control means permits of obturating a variable number of nozzles formed between blades l. We thus obtain, according to the number of elementary nozzles left in operation,

an adjustment of the section of nozzle g.

In the embodiment of Figure 4, the principle is the same, but shutter m is of circular section and pivots about an axis o, which undergoes the effort corresponding to the pressure difference existing on the respective faces of the shutter, which thus makes the operation extremely easy.

In all cases, nozzle g is placed at the end of the cockpit or engine nacelle and it is suitably directed, so that the jet of gas escaping through the nozzle is turned in the direction opposed to the direction of travel of the aircraft.

Figure 5 shows various other adjustment means which can be used either separately or in combination with that above described.

First, the pilot operates the throttle valve p provided on the intake and which may be combined with carburetter f. It is also possible to provide a control valve q in by pass b, so as to create a difference of pressure between the discharge of the compressor and the intake of the gas turbine, which thus produces an unbalance of the power of these two elements and consequently involves the acceleration of the group when valve q opens and a slowing down when it closes.

Furthermore, we may place, on the intake of the gas turbine or on the exhaust of engine a, a discharge r into the atmosphere provided with an adjustment valve s. When this valve is opened, a portion of the gases is deviated from the turbine, which therefore tends to reduce the speed of the group and consequently the supercharging of the engine.

In order to avoid complete loss of the gases thus discharged into the atmosphere, when the discharge port is to be opened for a long time, it is possible, either to provide this discharge port with a second reaction nozzle direction like the first one and therefore producing analogous effects, or to return the discharged gases into nozzle g, but behind that of the turbine. The gases can thus expand in said nozzle, adding their propelling effect to that of the gases which have passed through the turbine. This arrangement is the one shown in Figure 5.

As the efficiency of the reaction turbine is higher as the velocity of the gases which escape therefrom is closer to the velocity of the movement of the aircraft, and as the velocity of the gases is as a rule much higher than that of the aircraft, it is advantageous, in order to improve the efficiency, to produce in the reaction nozzle only a relatively small expansion, which, therefore corresponds to a relatively low drop of temperature of the gases.

As the exhaust gases of the engine are very hot, they carry along with them into the atmosphere a relatively important amount of heat, which is thus lost. In order to recuperate a portion of the power corresponding to this heat, the exhaust gases, upon leaving the gas turbine, may be mixed with a certain amount of air, previously compressed but which has not passed through the engine. This air is heated by mixing with the gases, and it expands in the nozzle together with said gases, which improves the propelling effect.

This air may be obtained at the outlet of the supercharging compressor, as shown by Figure 6. In this embodiment, the compressor is of the axial type, with helicoidal wheels t_1, t_2, t_2, t_3 and guides u_1, u_2, u_3. The air enters at e, is compressed by the compressor and is collected at the outlet in torus-shaped conduits v which leads it to the intake of the engine a. The discharge or exhaust of the engine is connected with the nozzles d of the gas turbine and upon leaving said turbine, the exhaust gases are mixed with the cold air directly discharged by the compressor through conduit w. This mixture of air and gas then expands in nozzle g to produce the propelling effect.

It may be desirable in order to obtain good efficiency, to collect the air which is not to flow through the engine at a pressure lower than that necessary for the supercharging of the engine. This results from the fact that, as above stated, the pressure that can be utilized in nozzle g is relatively low. Consequently, when the compressor is of the multi-stage type, it will be advantageous to take the air in question from an intermediate stage. Such an arrangement is shown in Figure 7. In this embodiment, the compressor is divided into two parts the first of which, x, acts on the whole of the air that is drawn in. This air is subsequently divided into two streams, one of which passes through the second part, y, of the compressor and serves in the supercharging of the engine. The exhaust gases from said engine drive turbine h and, upon leaving said turbine, are mixed with the cold air from compressor stage x, which has passed directly through conduits w. The mixture expands in nozzle g and produces the propelling effect.

When the compressor is of the centrifugal type, with a helicoidal intake wheel, it is particularly advantageous to take the by-pass air after said wheel, which already supplies sufficient pressure for feeding nozzle g.

In view of the difference of output and of pressure that is necessary for the two compression stages x and y, it may be

advantageous to constitute them by machines running at different speeds. Figure 8 shows an arrangement of this kind in which compressor y is driven directly by gas turbine h, for instance through a shaft common to both of them, while compressor x is driven through a gear train z which makes it possible to drive it at a different speed better adapted to the characteristics required therefrom.

The two elements of the compressor may also be driven by means of two gas turbines mounted in series and actuating said compressor elements through concentric shafts, the rotation taking place either in the same direction or in opposite directions.

As the drop of pressure utilized in the reaction nozzle is relatively low, the additional air may also be supplied even by the displacement of the aircraft in the atmosphere, without making use of a compressor. The air from the atmosphere enters, owing to its relative velocity, through an inlet orifice e^1 (Figure 9) in which a portion of its active force is transformed into pressure. It mixes with the hot gases coming from the exhaust of the turbine, which raise its temperature: then it expands, together with said gases, in nozzle g.

This produces positive work, although the expansion is in this case equal only to the relative velocity of the inflowing air, because, in the meantime the air has been heated and the speed it acquires in nozzle g for a given expansion is higher as its temperature is higher. This arrangement may even be employed in the case of an engine which is not supercharged, in which the heating of the air would be directly produced by mixing with the exhaust gases from the engine.

Of course, the various arrangements above mentioned in which there is provided an air by-pass leading behind the gas turbine can be employed in combination with a thermic engine the supercharging device of which also includes a by-pass connecting the intake and the exhaust of the engine, as shown in dotted lines by way of example in Figure 1, since, as above set forth, these two by-pass arrangements have different functions which complete each other.

In the various Figures of the drawings, the compressors are shown some of the axial type, some of the centrifugal type, but it should be well understood that any of the arrangements above described can be applied to compressors of any type whatever, axial, centrifugal, of a combined type or even volumetric.

Likewise, for the sake of simplicity, the exhausts of the engine cylinders have been shown as opening into a single conduit or manifold, but it is clear that when the number of cylinders of the engine is such that the exhausts interfere with one another, it would be advantageous to separate the exhaust manifold into several parts each of which corresponds to a group of cylinders the exhaust periods of which do not interfere with one another. In this case, the inlet torus-shaped member of the gas turbine will be partitioned into several portions each of which will receive the exhaust of one of these groups of cylinders.

A very interesting arrangement consists, in this case, in partitioning also the exhaust of the gas turbine, and also, eventually, the reaction nozzle. In fact, as this nozzle creates a counter-pressure, the exhaust gases from one of the cylinders, if it interfered with the end of the exhaust from another cylinder, would create a counter pressure in the gas turbine making it impossible to utilise the energy of this exhaust end suitably. Therefore, it is advantageous to partition both the intake and the exhaust of the gas turbine, as shown by Figure 10, which shows the development of a portion of the wheel.

In this Figure, the gases arrive through distinct conduits b_1 and b_2, are fed respectively to corresponding portions of distributing nozzles d_1 and d_2 drive wheel h and are collected, at the outlet in two chambers w_1 and w_2, each of which leads to a reaction nozzle g_1 and g_2, respectively. Of course, the partitions in the reaction nozzle need extend only to a point before the orifice where the gases have already acquired a velocity, in the direction of the flow, such that there is no possibility of creating a counter-pressure in the adjacent conduit.

While the above description discloses what we deem to be practical and efficient embodiments of the present invention, it will be understood that we do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A supercharging device for an aviation engine including an air compressor driven by a gas turbine actuated by the exhaust gases from said engine, characterised in that the exhaust gases, after passing through the turbine, are further expanded in a reaction nozzle opening in a direction opposed to that in which the aircraft is travelling, so as to

produce a propelling effect which adds itself to that of the airscrew driven by the engine.

2. A device according to Claim 1, further characterised in that the outlet section of the reaction nozzle can be modified so as to vary the power supplied by the propelling system.

3. A device according to either of the two preceding claims, further characterised in that a balance conduit is provided between the intake and the exhaust of the engine, preferably with means for controlling the flow through said conduit.

4. A device according to any of the preceding claims, further characterised in that a portion, preferably adjustable of the exhaust gases from the engine is by-passed ahead of the turbine and sent to the atmosphere without passing through said turbine, being preferably caused to flow through said reaction turbine.

5. A device according to any of the preceding claims, further characterised in that a portion of the compressed air supplied by said compressor is by-passed therefrom, at its outlet or preferably at an intermediate stage thereof, and sent to a point behind the turbine where it mixes with the exhaust gases thereof prior to expanding in the reaction turbine.

6. A device according to any of Claims 1 to 4, further characterised by the provision of means for adding to the gases escaping from the turbine, prior to their passage through the reaction nozzle, air compressed by the movement of the aircraft with respect to the atmosphere in an inlet of suitable shape.

7. A device according to any of the preceding claims, further characterised in that, if the exhausts of the cylinders of the engine were liable to interfere with one another and are accordingly led separately to the turbine, the gases flowing out from said turbine are also separated and led to distinct reaction nozzles or to the elements of a partitioned reaction nozzle respectively.

8. Supercharging devices for aircraft engine substantially as described with reference to the accompanying drawings.

Dated this 20th day of January, 1941.

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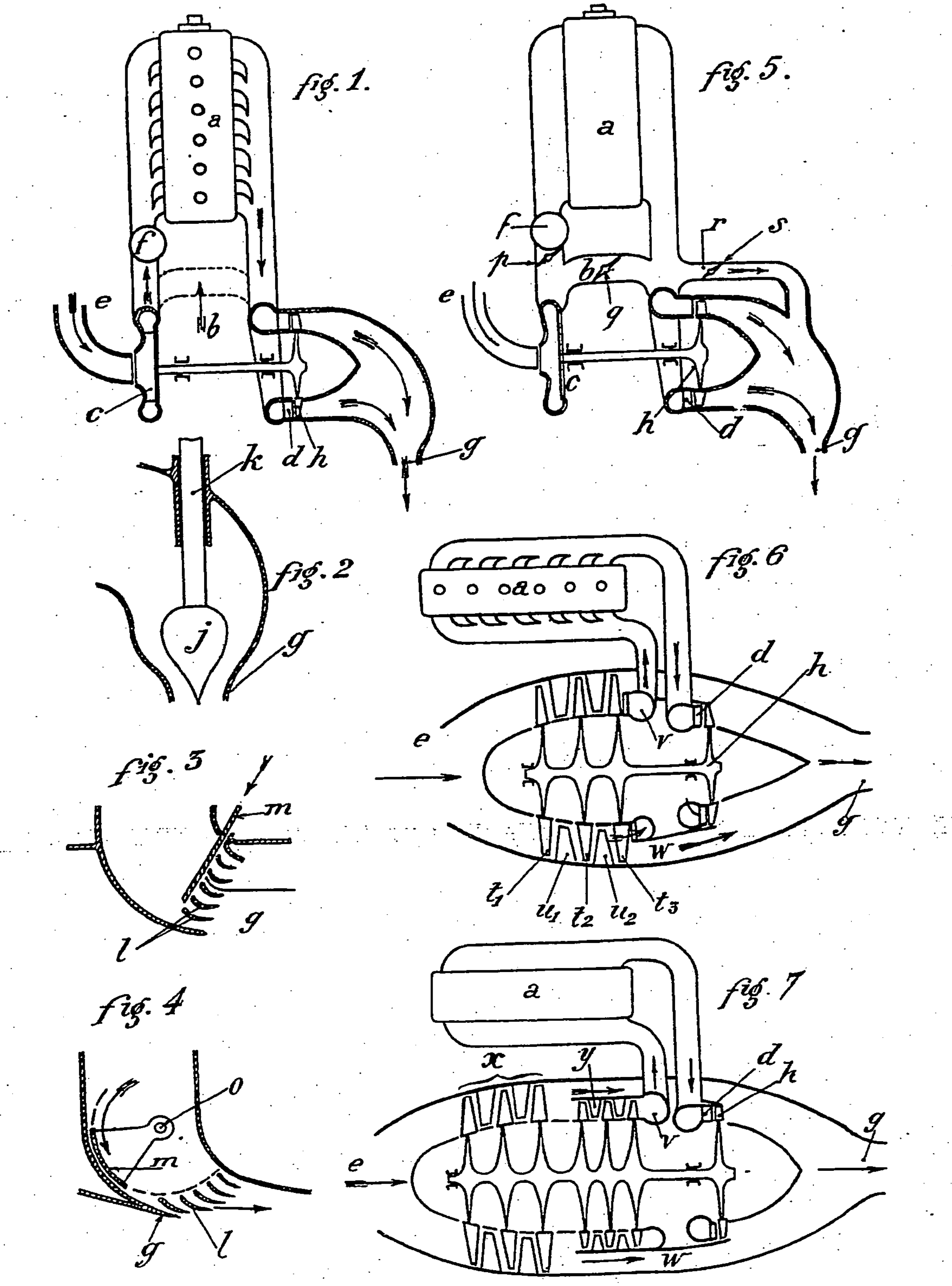

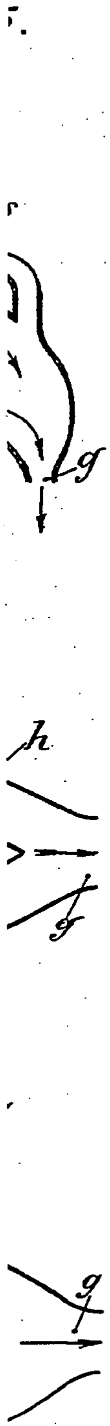

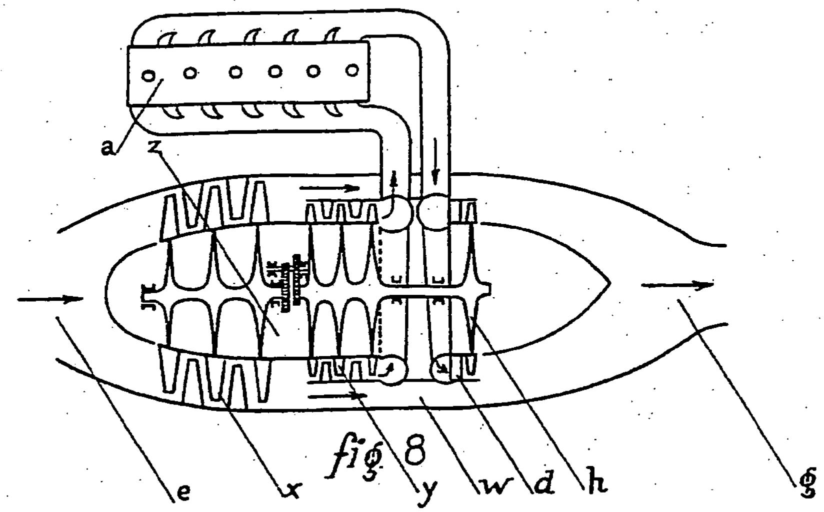

fig. 8

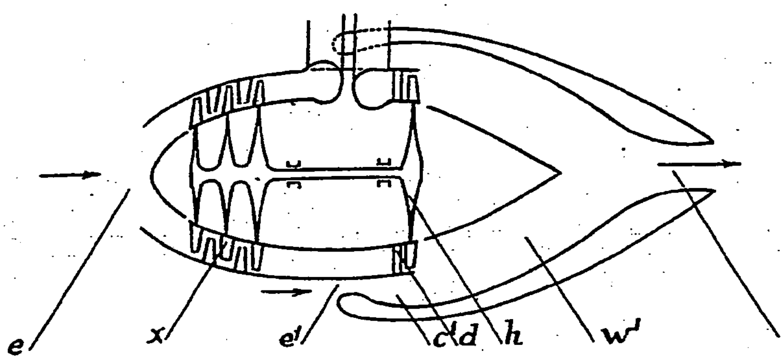

fig. 9

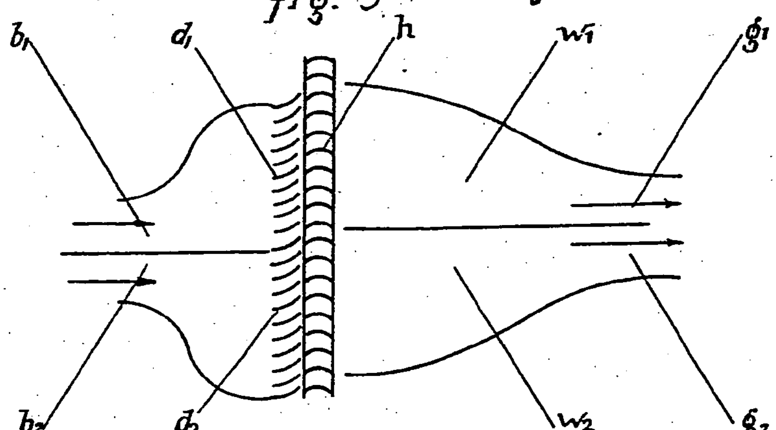

fig. 10

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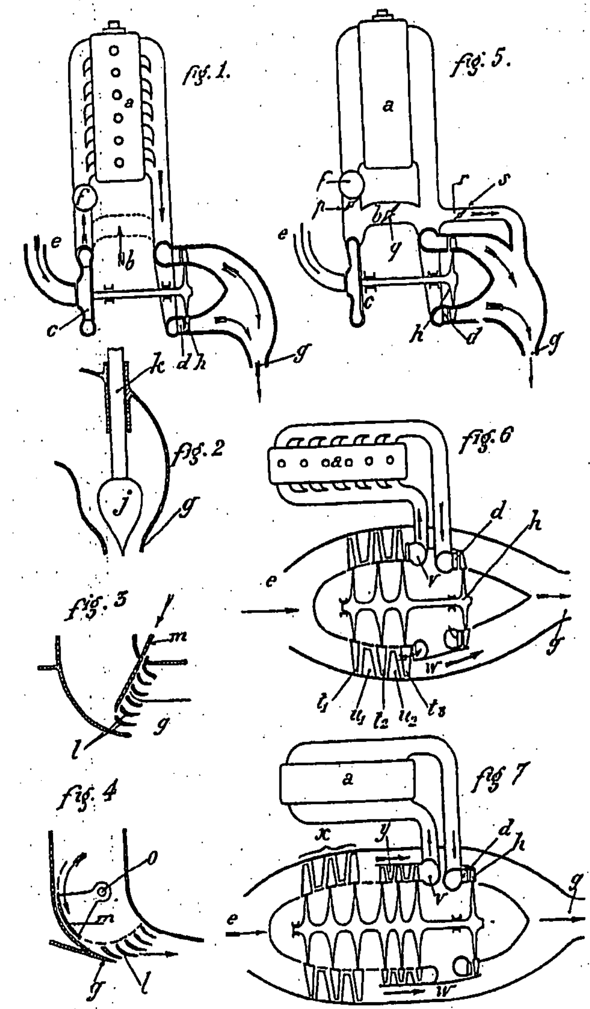
2 SHEETS
SHEET 2

SHEET 1



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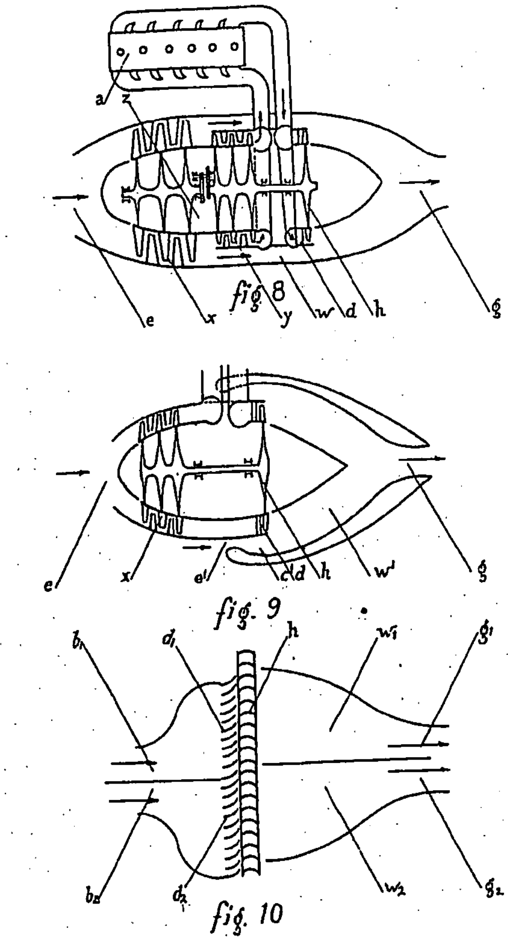

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